



# NGST Systems Engineering Report

## Thermal Subsystem 10

Title: <b>Radiator Requirements and Initial Heat Load Budget for the NGST Yardstick ISIM</b>	
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References:	

### Description

This SER documents the initial baselined heat load budget and radiator sizing requirements for NGST's integrated science instrument module's (ISIM) passively cooled near infrared detectors. These serve as starting points as the GSFC ISIM study gets underway.

### Heat Load Budget

Table 1 lists the preliminary heat load budget for the ISIM's NIR passive radiator. This budget serves as only a placeholder until the instrument design matures and details about various dissipations and mechanical details are known. The purpose of the budget is to carefully track the amount of heat the NIR radiator must dissipate. The sources of this heat is primarily from the NIR detectors themselves but also includes parasitic heat loads to the radiator via radiation, heat

**Table 1 ISIM NIR Radiator Preliminary Heat Load Budget**

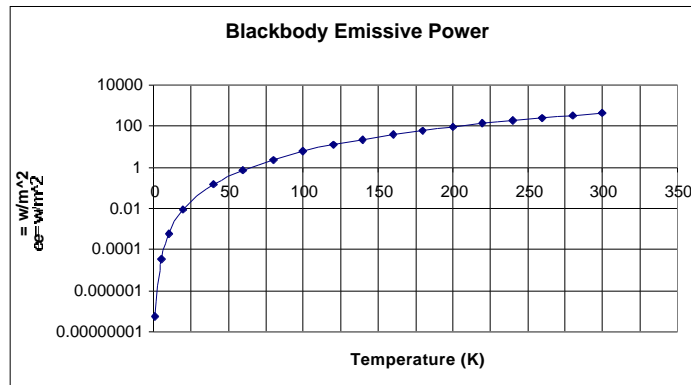
Source	Q (mW)	
Detectors Dissipation	160	
Detector Harness	5	
Residual Parasitics	30	
<i>via conduction and radiation to 2nd stage radiator</i>		
backloading from OTA	5	
<b>Total</b>	<b>200</b>	
Required capability	300	50% at concept stage

leaks through multi-layer insulation, via the structural supports and other physical connections to the radiators, backloading or environmental heating onto the radiator's external surface, and finally via any wiring or cabling to the detectors themselves. Each of these heat sources must be dutifully tracked and, in order for the ISIM to achieve passive thermal control, each heat source must be minimized through design. This initial or strawman budget has been used to estimate

the required radiator size at various detector temperatures from 30 to 35 K and to examine the amount of needed margin in the radiator sizing.

## Heat Load Design Margin

Preliminary concept studies for the ISIM over the past eighteen months by various parties have concluded that passively cooling the ISIM's NIR detectors is quite feasible to 35 K. What a majority of these studies failed to achieve is the proper amount of design heat load margin for a cryogenic thermal design. The studies also failed to address needed radiator sizes for detector temperatures below 35 K. A more likely temperature requirement for the NIR detectors is 32 K. When attempting to passively cool at these low temperatures, a slight change in the required



temperature dramatically impacts the needed radiator size. Figure 1 illustrates the challenges of

**Figure 1**

passively cooling at these temperatures by showing the maximum theoretical radiative capability versus temperature. Radiating capability at cryogenic temperatures is very inefficient. Thermal design margin for a passive cryogenic system is quantified by the amount heat load on the system versus what the system can reject at the desired operating temperature. An easy way to calculate margin is as follows:

$$\text{Heat Load Margin (\%)} = 100 \frac{T_{\text{design}}^4 - T_{\text{prediction}}^4}{T_{\text{prediction}}^4}$$

Typical guidelines require that the heat load margin be at least 50% at the concept design stage and gradually reduced to 35% at the critical design stage. Since passive cooling of the ISIM's NIR detectors impacts NGST's overall configuration and mission design, it is desirable at this stage to exceed the 50% margin. The heat load budget presented here as an example sums to 200 mW. Applying the 50% design margin results in a required radiator capability of 300 mW

## Radiator Size

Based on a 200 mW budget and the desire to have at least a 50% heat load margin, Figure 2 illustrates the needed radiator area for a range of design temperatures and for two different radiator emittances. Figure 2 is good at demonstrating the dramatic increase in required radiator size versus desired radiator temperature. Figure 3 depicts the same numerical information as Figure 2 but illustrates the radiator size dependence on heat load for three different operating temperatures with a radiator emittance of 0.7. As with desired operating temperature, there is a substantial radiator size sensitivity to heat load.

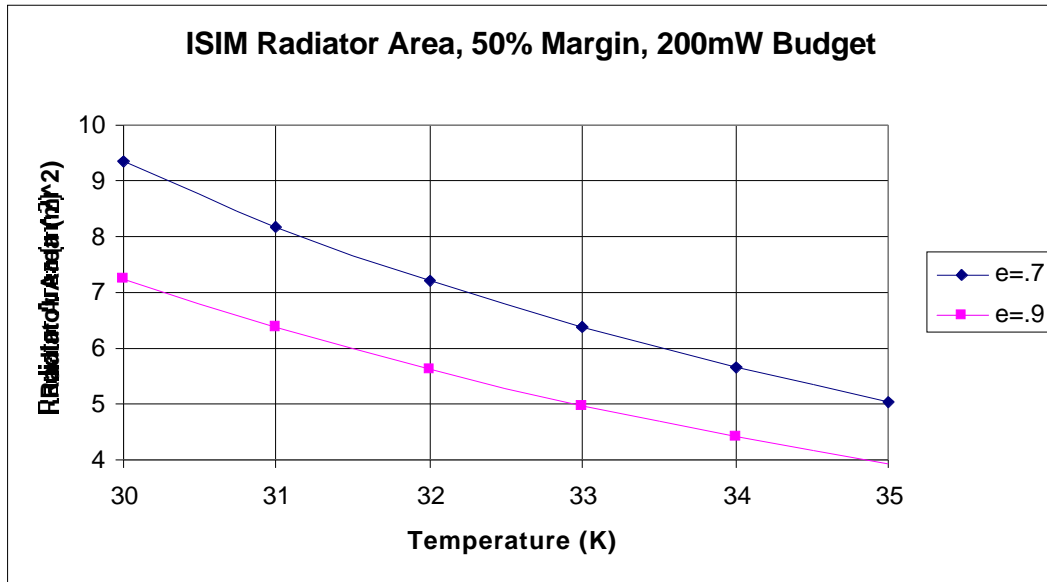


Figure 3

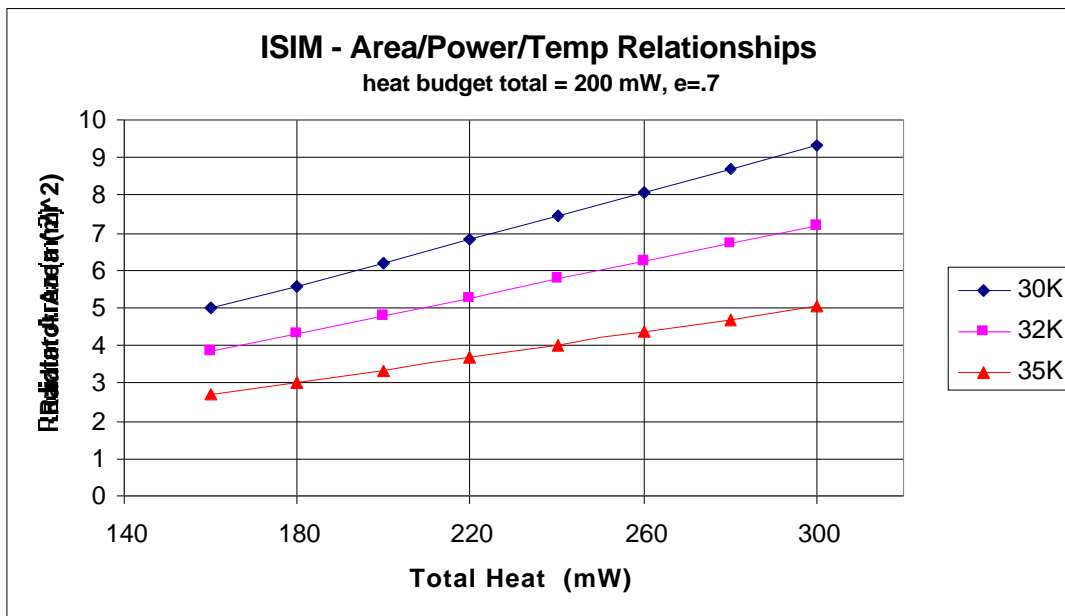


Figure 2